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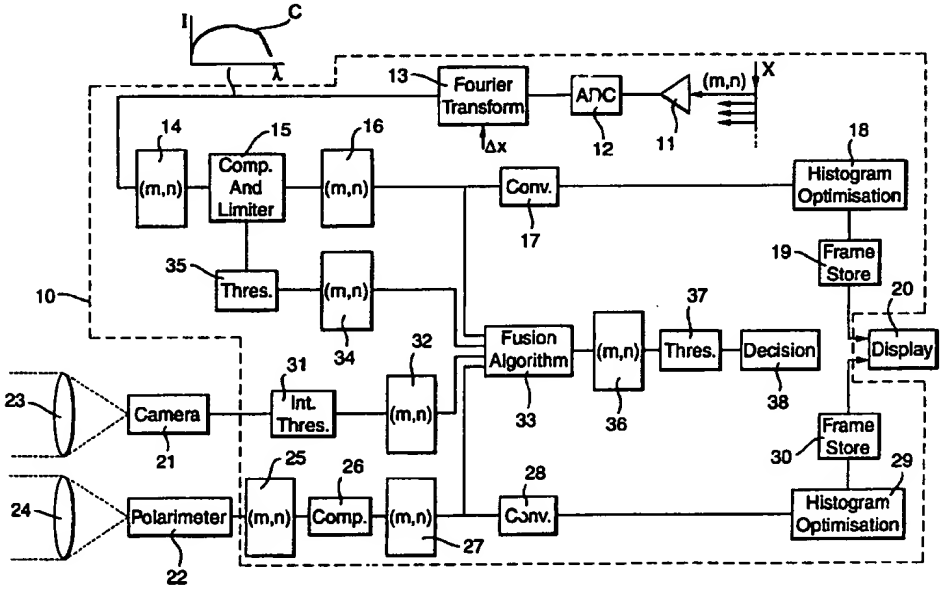
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: AN IMAGING SYSTEM



(57) Abstract: An imaging system is provided where radiation from object space (2) is incident on an array of detector elements (8) via an interferometer (3), the interferometer (3) being scanned such that the output of each pixel comprises an interferogram B generated from the radiation received from a corresponding region of object space (2), enabling image data to be generated in dependence on the output of the pixels, which image data is derived from the spectral radiance associated with each pixel.

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AN IMAGING SYSTEM

The present invention relates to an imaging system and more particularly to an imaging system suitable for the detection and classification of objects or gases using spectral radiance.

Cameras, whether they be conventional TV type cameras or infra-red cameras typically rely on generating an image dependant on the received intensity of radiation. However in addition to intensity a point in object space can also be characterised by its spectral radiance and polarisation.

There are a number of devices which enable spectral radiance to be detected, one type being preferentially doped large scale focal plane (FPA) arrays. FPA's can be doped in a manner which enhances the spectral response of certain pixels and is fixed at manufacture. Typically columns of detector elements are doped to have identical and defined narrow spectral responses. Over the full width of the array several sets of columns are provided to cover the waveband of interest, such devices being manufactured to cover the three to five and eight to twelve micron bands. The detector array operates as a set of long linear arrays and is scanned across the image to collect data at all relevant sub-bands to form a complete image. This provides an output which is in effect a set of images at each of the wavelengths of the sub-bands.

A disadvantage of the above system is that it requires a mechanical scanning device which is expensive, requires a significant power supply, poses a reliability problem and also requires a housing of sufficient dimensions for the scanning mechanism, all of which may be undesirable in some applications, particularly military applications.

A second type of imager by which an image may be generated based on spectral radiance employs a filter wheel placed directly in front of a focal plane array or wide band camera. The filter wheel contains a number of filters each having a narrow sub-band transmission and these filters are placed in front of the detector in sequence to generate a series of separate images one for each sub-band. Again the use of a rotating filter wheel is not desirable and also with this system the image may require several cycles of the filter wheel to allow an integration to take place because the integration time for each sub-band will be short to ensure that the complete set of sub-bands is sampled in a short time compatible with a CCIR TV format (frame Rate 25Hz). With 10 or 12 sub-bands the time interval between separate sub-band samples is typically of the order of 0.5 of a second and is fixed. The time interval between separate samples through the sub-band is also long and fixed and the disadvantage of this is that the lack of flexibility prevents the sub-bands in which "contrast" or target discriminant has been detected being revisited more frequently.

A third imager type used in satellite applications employs an interferometric technique which is optimised for specific wavelengths and is subject to a set of

unique constraints related to operation in space where there is no vibration environment to cause misalignment (except at launch), no atmosphere attenuation within the instrument, and the interferometer is only likely to be scanned if a range of wavelengths are to be examined, otherwise it could be fixed or tuned.

According to the present invention there is provided an imaging system comprising an aperture for receiving radiation from object space, an interferometer arranged such that radiation received through the aperture is incident thereon, an array of detector elements for receiving output radiation from the interferometer, a controller arranged to scan the interferometer through a range of different path lengths and a processor for receiving signals from a plurality of elements of the array, the process determining a spectral radiance for each of a plurality of pixels, each pixel corresponding to one or more elements of the array, and generating image data, the grey scale of which is determined by the spectral radiance of each pixel.

By employing the present invention the spectral radiance, the wavelength of photons received by the imaging system, can be accurately determined to a resolution determined by the length of the interferometer arms but constrained to a reasonable value by typical size constraints appropriate to airborne military equipment. This may enable boundaries between objects to be detected which would not be possible using conventional broad band techniques. The data obtained may also be used to enable a material or gas to be identified from its unique spectral radiance characteristics permitting materials of particular interest to an observer to be flagged

up by subsequent processing techniques.

Preferably the processor performs a Fourier transform to ascertain the spectral radiance of each pixel, the spectral radiance of a plurality of pixels advantageously being determined simultaneously. This can be used to enable a real time image to be generated, and preferably the system further comprises an image generator generating an image in which the grey scale is dependant on the spectral radiance of each pixel. The grey scale image can be enhanced prior to being displayed as a colour image in accordance with known techniques.

Where the signal received from object space is weak then the interferometer is preferably scanned a plurality of times in order to enable spectral radiance of the pixels to be ascertained. Also depending on application it may be desirable to perform a non-uniform scan in the time domain with the interferometer to emphasise parts of the sub-band of special interest whilst suppressing parts with less interesting characteristics.

A non-uniform scan occurs when the length of a variable arm of the interferometer is increased in a non-linear manner by introduction, for example of a step function change in position.

In certain applications it is preferable to employ an interferometer which is a solid state device for this avoids the need for any moving parts associated with the

interferometer and may enable the complete imager to be a solid state device, a solid state device tending to be more reliable and rugged than a mechanical counterpart. To ensure against mis-alignment the optical elements of the interferometer may employ corner cubes as reflectors.

Where the interferometer is a solid state device it preferably comprises a material the refractive index of which may be changed by controlling an electric field across it, such materials being known as an electro-optic modulator, examples being Lithium Niobate and Galium Arsenide. The path length of one leg of the interferometer can be altered by the varying the refractive index of the material by any external means.

To assist in the detection of objects it is preferable that the processor performs an inter array comparison which is best carried out with the interferogram (rather than its Fourier Transform which is the spectral radiance) and a set of standard interferograms stored in a data base, by means of a standard real time correlator. This allocates to each pixel a specific spectral content partly in dependance on the spectral radiance of other pixels. The processor may perform a histogram manipulation according to standard techniques, on spectral radiance values and allocate a grey scale to each pixel in dependance on the number of pixels having a value in any one range in order to maximise grey scale contrast. Such a technique results in all pixels having a similar spectral radiance being assigned a certain grey scale value making any shape comprising those pixels easier to identify in a resultant image. Alternatively an equivalent technique would be to associate the histogram

with a range of colours and create a false colour image.

Advantageously the system may further comprise a polarimeter for receiving radiation from the same object space as radiation received by the interferometer, the processor combining data received from the polarimeter with that data received from the array of detector elements to obtain a score for each pixel. Similarly, or in addition to, the system may further comprise a camera for receiving radiation over the range of wavelengths of interest from the same object space as radiation is received by the interferometer. The output of the camera may then provide intensity data which is combined by the processor with that received from the said array of detector elements to obtain a score for each pixel. The data from the different sources is preferably combined by a fusion algorithm based on standard statistical techniques within the processor, the score attained representing the level of interest for a particular pixel. For example a particular pixel or group of pixels will score highly if the spectral radiance and/or polarisation and/or intensity is substantially different to that of adjacent pixels since such an event would imply an anomaly in target space that would be worth considering/investigating further.

One embodiment of the present invention will now be described by way of example with reference to the accompanying drawings of which:

Figures 1A and 1B illustrate an imaging system in accordance with the present invention;

Figure 2 is an exemplary spectral radiance plot for one particular pixel;

Figure 3 is a schematic representation of the data generated by the imaging system of Figures 1A and 1B.

Referring to Figure 1A an imaging system in accordance with the present invention comprises an aperture 1 for receiving an image from object space, represented by grid 2. Radiation received through the aperture 1 enters Michelson interferometer 3 where it is split into two optical paths by semi silvered optic 4. The first optical path passes through compensation element 5 to mirror 6 where it is reflected back through the compensation element 5, off the semi silvered surface of mirror 4 through collimator 7 to be incident on an array of the detector elements 8 at the focal plane.

The second optical path is reflected off the rear surface of semi silvered optic 4 to optical element 9. This comprises a material the refractive index of which is controlled by an applied electric field. Light passing through the material is reflected off the silvered rear surface back through the material and a change in the path length is introduced by progressively altering the applied voltage. This is equivalent to scanning a mirror through a distance Δx. The second optical path then passes through semi silvered optic 4 and is recombined with the first optical path such as to cause constructive and destructive interference depending on the relative phase of the light in the two optical paths.

The focal plane array comprises a two dimensional array of detector elements, each detector element (m,n) defining a pixel (m,n) corresponding to a region of object space represented by one square of grid 2. As the path length of one leg of the interferometer is varied by Δx the spectral radiance associated with each region of object space causes an interference pattern to be generated, such that the associated detector element (m,n) of the array detects a series of fringes passing across it, resulting from constructive and destructive interference of the two light paths within the Michelson interferometer 3. Thus the spectral radiance from object space corresponding to pixel (m,n), represented by graph A, generates an optical interferogram for pixel (m,n) where the intensity detected by the detector element is a function of Δx, as represented by graph B. This output for each pixel is received at the input X of a processor illustrated generally by the broken line 10 of Figure 1B.

Referring to now to Figure 1B, the function of the processor is schematically represented by the components contained within broken line 10. In practice the processor may be implemented by any suitable processing means, and may typically one or more micro processors which could be at separate locations. Also the processing may or may not be done in real time. The data received at input X could be received from a storage medium or directly from the focal plane array 8 as shown.

The processor of Figure 1B controls displacement Δx of mirror 9. The signal

received at X containing data from each element (m,n) of the display is first amplified by amplifier 11 and then converted to a digital signal by analogue to digital converter 12. A Fourier transform 13 is performed providing a spectral radiance for each pixel (m,n) as a function of Δx as indicated by graph C. A typical spectral radiance for an element (m,n) may be as illustrated in Figure 2. Referring again to Figure 1B the pixel spectral radiance for each element (m,n) is stored in data file 14. An intra-array comparison 15 is made of the data within data file 14 to identify pixels having similar values and also to set a limit for associating different pixels with the same spectral content, which limit is a function the noise level of the data and range of the data, in accordance with standard image processing techniques such as an adaptive convolution filter.

Each pixel is thus assigned a spectral data type which is stored in data file 16, the value being selected from one of a set comprising no more than, for example 256 which would match a conventional grey scale display. These values are then converted to a grey scale 17 on which a histogram optimisation is performed to maximise the contrast between the grey levels, before being transferred to frame store 19 prior to display on display 20.

In addition to receiving data from input X the processor 10 also receives inputs from a wide band camera 21 and polarimeter 22 both accurately aligned to view to the same object space, via lens apertures 23 and 24 respectively, such that the pixel output of both the camera and polarimeter correspond to that of the focal plane array 8 of Figure 1A.

From the output of the polarimeter 22 a pixel polarisation state data file 25 is generated on which data an intra-array comparison 26 is performed to assign a pixel polarisation type to each pixel, which type is stored in data file 27. This is converted to a grey scale, 28, on which histogram optimisation is performed, 29, and the resultant data stored in frame store 30 for display on the display 20. This enables an operator to switch between an image generated from the spectral radiance of a scene and an image generated from polarisation data of the same image. The operator may switch between images by manual intervention or the images may be fused to provide a composite image based on the key features of each image.

The output of camera 21 provides the intensity data for block 31. An intensity threshold is applied at 31 and the pixel intensity is stored in a data file 32.

From the output of block 31 a wide band pixel intensity data file 32 is generated. The content of this data file 32 together with the content of both the pixel polarisation type data file 27 and the pixel spectra type data file 16 is combined by fusion algorithm 33. This algorithm also receives an input from a spectral anomaly data file 34 the content of which is derived from the output of the intra-array comparator and limiter 15, any anomalies identified by the comparator and limiter above a predetermined threshold, 35, being stored in the spectral anomalies data file 34which contains a list of all pixels which have a spectral radiance different, as set by threshold 35, from the background and neighbouring pixels.

The fusion algorithm 33 processes the received data in accordance with parameters set by the user dependent on the application of the user. The fusion algorithm 33 will produce a score in data file 36 for each pixel, all scores above a threshold, 37, being identified by decision block 38 the output of which can be used either to the flag areas of interest on the display 20 or can identify areas of image which warrant further investigation. The fusion algorithm will produce a score dependent on the relative magnitude of each of the three inputs. A high score will result from a simultaneously measured spectral anomaly, polarisation anomaly and intensity anomaly.

Referring to Figure 3 there is illustrated a three dimensional hyper cube created from the data contained within the pixel spectral radiance data file 14 of Figure 1B. The x and y axis of the hyper cube represent the pixel position in object space, and wavelength is given along the z axis. For any one pixel the spectral radiance may be derived with respect to wavelength, and in the illustrated example three sections 40, 41, and 42 taken through the hyper cube are illustrated with average spectral radiance plots for each. Each spectral radiance plot can be compared with that for a known object, enabling the type of object or gas to be identified. Such a comparison process may be performed as a consequence of the output of decision block 38 determining that a particular pixel within the image is of interest.

The spectral radiance of typical scenarios will depend on the time of day and the

vegetation cover or nature of ground filling the field of a view of the instrument. This information is used to set the spectrometer resolution and other operating parameters. This is carried out in the processor. An average spectral radiance is calculated and compared with a small data set to establish the best match. This is used to set the operating parameters in a manner which will optimise the sensitivity of the instrument in the detection of anomalies.

The three dimensional hyper cube may be created for polarisation state or intensity as well as for spectral radiance. A five dimensional hyper cube can be created in a suitable mathematical form but cannot be represented in an easily comprehensible manner.

One embodiment of the present invention has been described above by way of example only. However it will be appreciated that the data obtained from the focal plane array 8 of Figure 1A can be processed in other ways whilst still within the scope of the appended claims.

CLAIMS

1. An imaging system comprising:

an aperture for receiving radiation from object space;

an interferometer arranged such that radiation received through the aperture is incident thereon;

an array of detector elements for receiving output radiation from the interferometer;

a controller arranged to scan the interferometer through a range of different path lengths; and

a processor for receiving signals from a plurality of elements of the array, determining a spectral radiance for each of a plurality of pixels, each pixel corresponding to one or more elements of the array, and generating an image, the grey scale of which is determined by the spectral radiance of each pixel.

2. A system as claimed in Claim 1 where in the array of detector elements is a two dimensional focal plane array.

3. A system as claimed in Claim 1 or 2 wherein the processor performs a Fourier transform to obtain the spectral radiance of each pixel.

4. A system as claimed in Claim 2 or 3 wherein the spectral radiance for a plurality of pixels is determined simultaneously.

5. A system as claimed in any preceding claim further comprising an image generator for generating an image in which the grey scale is dependent on the spectral radiance of each pixel.

6. A system as claimed in any preceding claim wherein the interferometer is scanned a plurality of times to obtain the spectral radiance of the pixels.

7. A system as claimed in any preceding claim wherein the interferometer scan is non uniform.

8. A system as claimed in any preceding claim wherein the interferometer is a solid state device.

9. A system as claimed in Claim 8 wherein the interferometer comprises a material the refractive index of which may be changed by controlling an electric field across it and wherein the path length of one leg of the interferometer is altered by varying the refractive index of the material.

10. A system as claimed in any preceding claim comprising a display and

wherein the spectral radiance data is processed to provide on the display a pseudo three dimensional cube with two perpendicular axes corresponding to the coordinates of the image and the third mutually perpendicular axis corresponding to wavelength of radiation received.

11. A system as claimed in any preceding claim wherein the processor performs an intra-array comparison and allocates each pixel a specific spectral content partly in dependance on the spectral radiance of other pixels.

12. A system as claimed in any preceding claim wherein the processor performs a histogram manipulation on the spectral radiance value and allocates a grey scale to each pixel in dependance the number of pixels having a value in any one range to maximise grey scale contrast.

13. A system as claimed in any preceding claim further comprising a polarimeter for receiving radiation from the same object space as radiation is received by the interferometer, the processor combining data received from the polarimeter with that received from said array of detector elements to obtain a score for each pixel.

14. A system as claimed in any preceding claim further comprising a camera for receiving radiation over the range of wavelengths of interest from the same object space as radiation is received by the interferometer, the output of the

camera providing intensity data which is combined by the processor with that received from the said array of detector elements to obtain a score for each pixel.

15. A system as claimed in Claim 13 or 14 wherein the data from the different sources is combined by a fusion algorithm contained within the processor.

16. An imaging system substantially as hereinbefore described with reference to and/or as illustrated in the accompanying Figures.

Fig.1A.

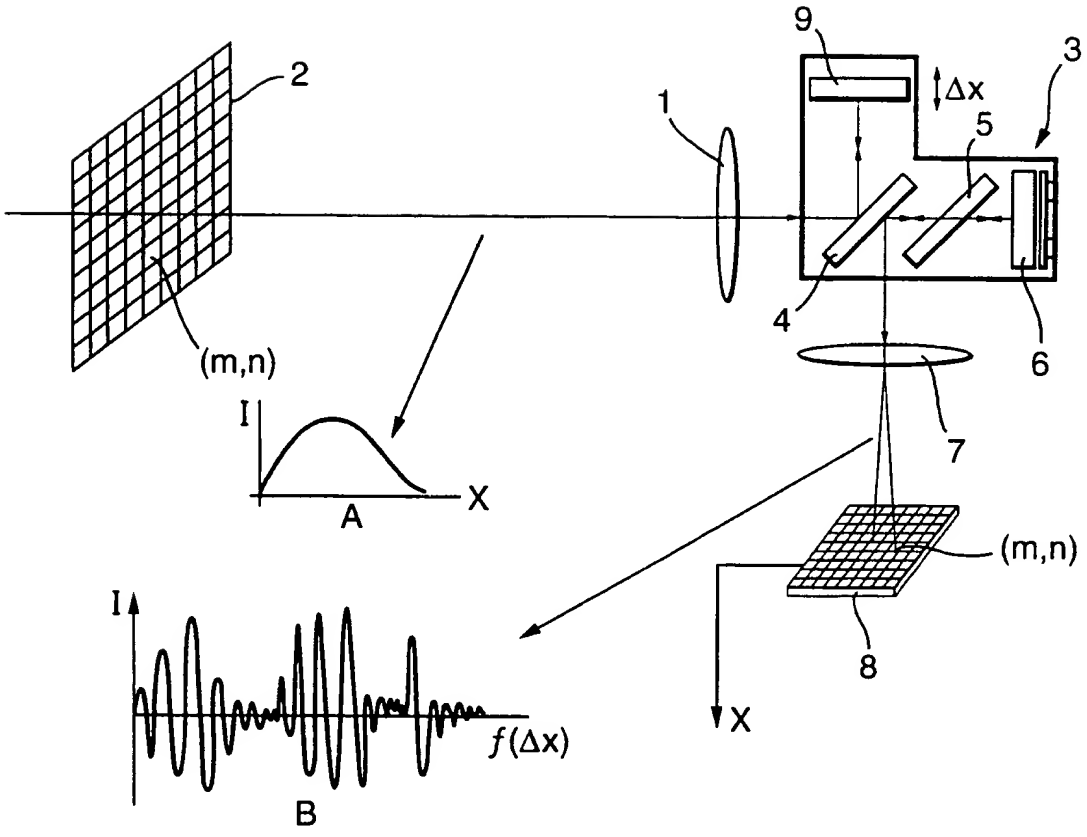


Fig.1B.

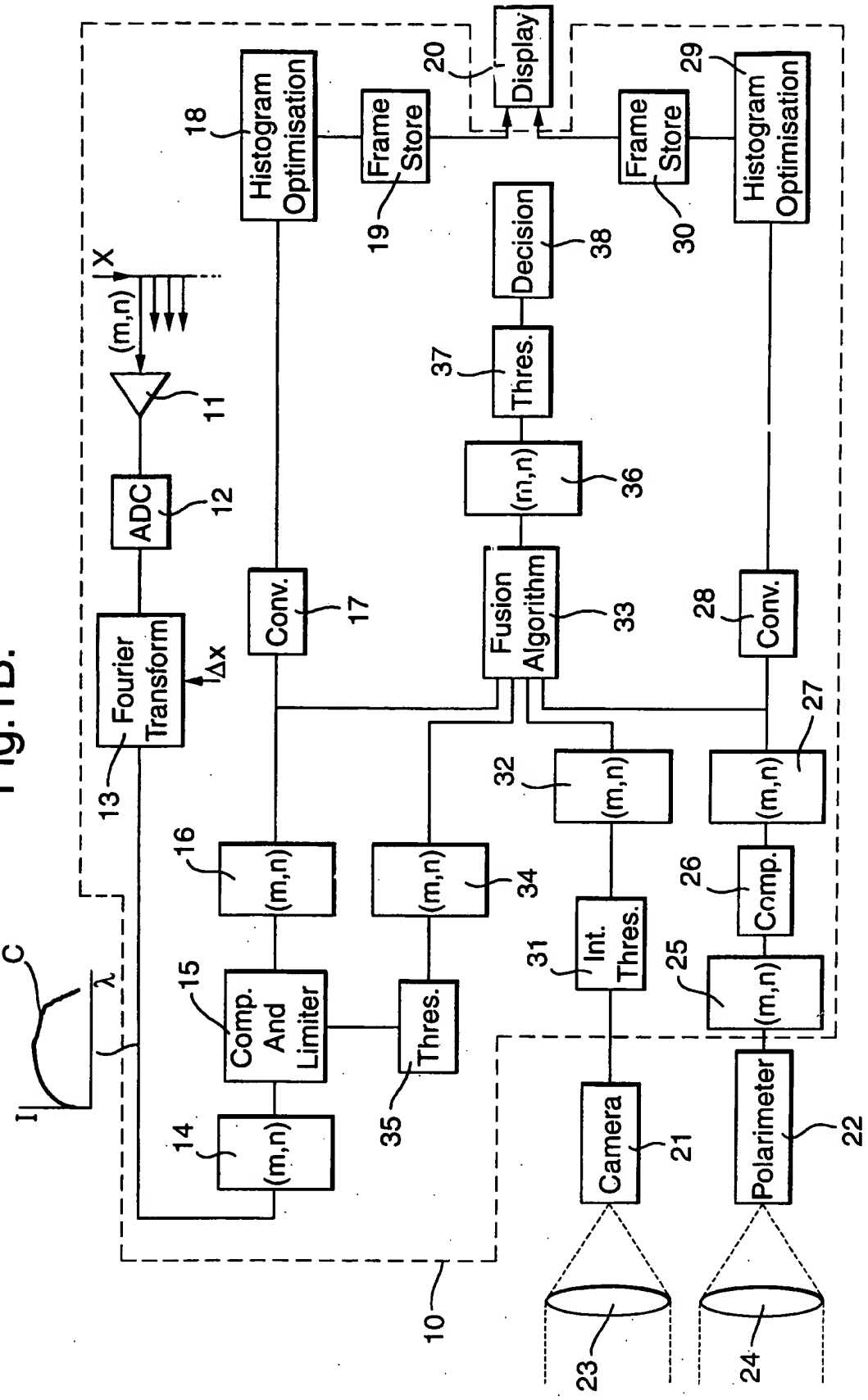

Display
20
Histogram Optimisation
18
Frame Store
19
Frame Store
30
Histogram Optimisation
29
Decision
38
Thres.
37
(m,n)
36
Fusion Algorithm
33
Conv.
17
Conv.
28
Fourier Transform
13
Δx
ADC
12
11
X
(m,n)
C
λ
I
(m,n)
16
(m,n)
34
(m,n)
32
(m,n)
27
Comp. And Limiter
15
Thres.
35
Int. Thres.
31
Comp.
26
(m,n)
14
(m,n)
25
Camera
21
Polarimeter
22
10
23
24

Fig.2.

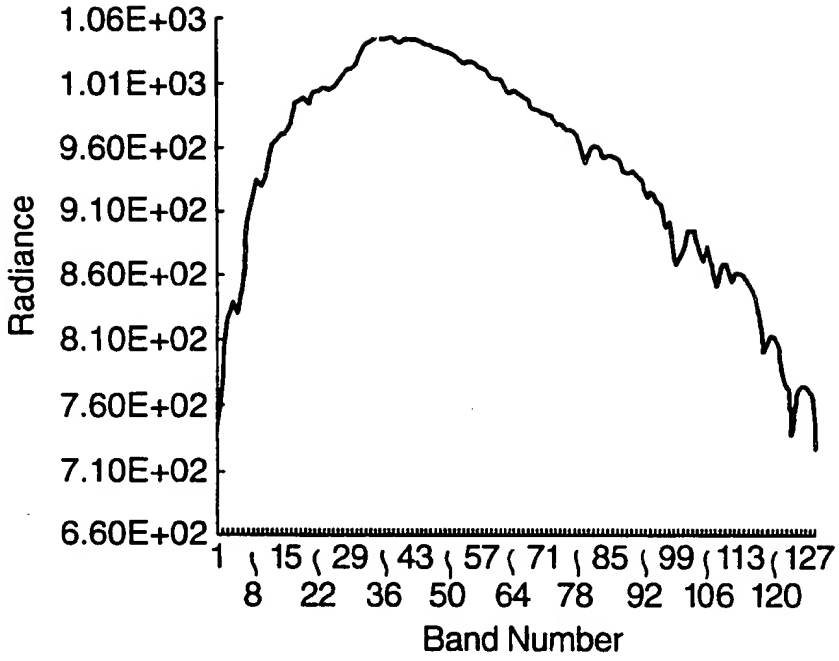
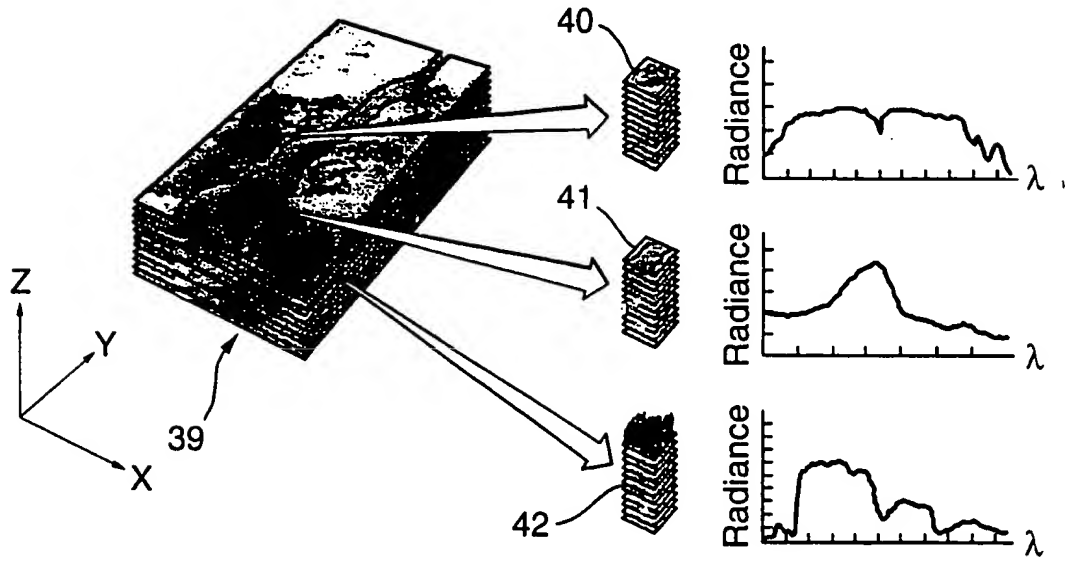

1.06E+03
1.01E+03
9.60E+02
9.10E+02
8.60E+02
8.10E+02
7.60E+02
7.10E+02
6.60E+02
Radiance
1 8 15 22 29 36 43 50 57 64 71 78 85 92 99 106 113 120 127
Band Number

Fig.3.


40
41
42
39
Z
Y
X
Radiance
λ
Radiance
λ
Radiance
λ

09/170-859

PCT/GB00/03706

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 12 June 2001 (12.06.01)	
International application No. PCT/GB00/03706	**Applicant's or agent's file reference** X61703
International filing date (day/month/year) 27 September 2000 (27.09.00)	**Priority date** (day/month/year) 30 September 1999 (30.09.99)
Applicant JACK, James, Wynd	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

17 April 2001 (17.04.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Zakaria EL KHODARY
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

MM1

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

To:
BAE SYSTEMS Group IP Departement
Attn. Rooney, P.
Lancaster House P.O. Box 87
Farnborough Aerospace Centre
Farnborough, Hampshire GU14 6YU
UNITED KINGDOM

Date of mailing *(day/month/year)*	12/01/2001
Applicant's or agent's file reference: X61703	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No.: PCT/GB 00/ 03706	International filing date *(day/month/year)* 27/09/2000
Applicant: BAE SYSTEMS AVIONICS LIMITED et al.	

// DIAR 12/3/01

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bakari Mwamboga

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the International application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
X61703		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 00/ 03706	27/09/2000	30/09/1999
Applicant		
BAE SYSTEMS AVIONICS LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readble form.

[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1B

[X] as suggested by the applicant.

[ ] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

[ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/03706

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01J3/28 G01J3/453

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 767 361 A (BUCKWALD ROBERT A ;CABIB DARIO (IL); FRIEDMAN ZVI (IL); C I SYSTEM) 9 April 1997 (1997-04-09)	1-4,8,16
Y	page 4, line 40 -page 5, line 25 page 7, line 47 -page 8, line 47	5-7, 9-12,14, 15
Y	WO 99 28856 A (GARINI YUVAL ;KATZIR NIR (IL); APPLIED SPECTRAL IMAGING LTD (IL);) 10 June 1999 (1999-06-10) page 3, line 7 - line 24 page 16, line 17 -page 21, line 2	5-7,9-12
Y	US 5 528 368 A (LEWIS EDGAR N ET AL) 18 June 1996 (1996-06-18) column 9, line 45 - line 48 column 10, line 28 - line 38	14,15

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 January 2001	12/01/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Jacquin, J

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/03706

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 977 787 A (FLETCHER JAMES C ADMINISTRATOR ET AL) 31 August 1976 (1976-08-31) the whole document	13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 00/03706

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0767361 A	09-04-1997	US 5539517 A	23-07-1996
		AT 189927 T	15-03-2000
		DE 69327909 D	30-03-2000
		DE 69327909 T	13-07-2000
		EP 0957345 A	17-11-1999
		EP 0957346 A	17-11-1999
		ES 2144441 T	16-06-2000
		GR 3033470 T	29-09-2000
		US 6066459 A	23-05-2000
		US 5784162 A	21-07-1998
		US 5936731 A	10-08-1999
		US 5817462 A	06-10-1998
		US 5719024 A	17-02-1998
		US 5856871 A	05-01-1999
		US 5991028 A	23-11-1999
		US 5835214 A	10-11-1998
		US 5798262 A	25-08-1998
		US 6018587 A	25-01-2000
		US 6055325 A	25-04-2000
		US 5912165 A	15-06-1999
		US 5906919 A	25-05-1999
WO 9928856 A	10-06-1999	US 5995645 A	30-11-1999
		AU 1610299 A	16-06-1999
		EP 1042727 A	11-10-2000
US 5528368 A	18-06-1996	US 5377003 A	27-12-1994
		US RE36529 E	25-01-2000
US 3977787 A	31-08-1976	JP 52007288 A	20-01-1977

700809

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PATENT COOPERATION TREATY

REC'D 20 DEC 2001

WIPO PCT

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

RECEIVED
FEB 1 2002
TC 2800 MAIL ROOM

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
X61703		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/03706	27/09/2000	30/09/1999
International Patent Classification (IPC) or national classification and IPC G01J3/28		
Applicant BAE SYSTEMS AVIONICS LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
17/04/2001	18.12.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Artelsmair, G Telephone No. +49 89 2399 8989

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03706

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1,2,4-12	as originally filed			
3,3a	as received on	13/09/2001	with letter of	12/09/2001

Claims, No.:

1-14	as received on	13/09/2001	with letter of	12/09/2001

Drawings, sheets:

1-3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☒ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)
   see separate sheet

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-14
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-14
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-4
	No:	Claims	

2. Citations and explanations
   see separate sheet

Preliminary remark:

Claim 1 includes the features that the system comprises "at least one other imaging apparatus". Thus, according to the present wording of claim 1 any imaging apparatus could be combined with the interferometer. However, the specification as originally filed only mentions a polarimeter and/or a camera. There is no basis for basis for the claimed generalisation in the specification as originally filed. The following comments are made under the assumption, that this objection is overcome.

Nearest prior art is EP-A-0767361 (D1) from which claim 1 starts in its preamble.

The other documents cited in the International Search Report are only relevant for dependent claims or as general technological background.

The subject matter of claim 1 differs from what is described in D1 mainly in that the system furtherer comprises at least one other imaging apparatus, i.e. a polarimeter and/or a camera. It is true that the spectroscopic microscope described in US-A-5528368 (D3) includes a camera in addition to a detector. However, according to D3 the image may be presented to the detector or to the camera. This is quite different to claim 1, which specifies that a camera and/or a polarimeter is provided for receiving radiation from the same object space as the interferometer, to combine the data from the camera and/or the polarimeter the data received from the interferometer and to obtain a score for each pixel. By doing so areas of particular interest to an observer can be fagged. This is neither known from, nor obviously derivable from the available prior art.

unique constraints related to operation in space where there is no vibration environment to cause misalignment (except at launch), no atmosphere attenuation within the instrument, and the interferometer is only likely to be scanned if a range of wavelengths are to be examined, otherwise it could be fixed or tuned.

EP-A-0 767 361 discloses an imaging spectrometer which includes an interferometer whose output is focussed on a detector array to determine the spectral intensity of each pixel in a scene. The output from the interferometer comprises modulated light corresponding to a predetermined set of linear combinations of the spectral intensity of light emitted by each pixel of the scene.

According to the present invention there is provided an imaging system comprising:-

an aperture for receiving radiation from object space; an interferometer arranged such that radiation received through the aperture is incident thereon; an array of detector elements for receiving output radiation from the interferometer; and a controller for scanning the interferometer through a range of different path lengths, for receiving signals from a plurality of elements of the array, for determining a spectral radiance value for each of a plurality of pixels, each pixel corresponding to one or more elements of the array, and for generating a grey scale image in accordance with the spectral radiance of each pixel; characterised in that the system further comprises at least one other imaging apparatus for receiving radiation from the same object space as the interferometer, and in that the controller combines data received from each other imaging apparatus with that received from the array of detector elements to obtain a score for each pixel.

By employing the present invention the spectral radiance, the wavelength of photons received by the imaging system, can be accurately determined to a resolution determined by the length of the interferometer arms but constrained to a reasonable value by typical size constraints appropriate to airborne military equipment. This may enable boundaries between objects to be detected which would not be possible using conventional broad band techniques. The data obtained may also be used to enable a material or gas to be identified from its unique spectral radiance characteristics permitting materials of particular interest to an observer to be flagged

CLAIMS

1. An imaging system comprising:-

an aperture (1) for receiving radiation from object space (2);

an interferometer (3) arranged such that radiation received through the aperture (1) is incident thereon;

an array (8) detector elements for receiving output radiation from the interferometer (3); and

a controller (10) for scanning the interferometer (3) through a range of different path lengths, for receiving signals from a plurality of elements (m, n) of the array (8), for determining a spectral radiance value for each of a plurality of pixels, each pixel corresponding to one or more elements of the array (8), and for generating a grey scale image in accordance with the spectral radiance of each pixel;

characterised in that the system further comprises at least one other imaging apparatus (21, 22) for receiving radiation from the same object space (2) as the interferometer (3), and in that the controller (10) combines data received from each other imaging apparatus (21, 22) with that received from the array (8) of detector elements to obtain a score for each pixel.

2. A system as claimed in Claim 1, wherein said at least one other imaging apparatus (21, 22) comprises a polarimeter (22).

3. A system as claimed in Claim 1 or 2, wherein said at least one other imaging apparatus (21, 22) comprises a camera (21).

4. A system as claimed in any preceding claim, wherein the controller (10) contains a fusion algorithm stage (33) for combining the data received from the array (8) with that from each of the other imaging apparatus (21, 22).

5. A system as claimed in any preceding claim, wherein the array (8) of detector elements (m, n) comprises a two-dimensional focal plane array.

6. A system as claimed in any preceding claim, wherein the interferometer (3) is scanned a plurality of times to obtain the spectral radiance of the pixels.

7. A system as claimed in any preceding claim, wherein the scan of the interferometer (3) is non-uniform.

8. A system as claimed in any preceding claim, wherein the interferometer (3) is a solid state device.

9. A system as claimed in Claim 8, wherein the interferometer (3) comprises a material the refractive index of which may be changed by controlling an electric field across it and wherein the path length of one leg of the interferometer (3) is altered by varying the refractive index of the material.

10. A system as claimed in any preceding claim, wherein the controller (10) includes a Fourier transform stage (13) for obtaining the spectral radiance of each pixel.

11. A system as claimed in Claim 10, wherein the spectral radiance for a plurality of pixels is determined simultaneously.

12. A system as claimed in any preceding claim, further comprising a display (20) and wherein the spectral radiance data is processed to provide on the display (20) a pseudo three dimensional cube with two perpendicular axes corresponding to the coordinates of the image and the third mutual perpendicular axis corresponding to wavelength of radiation received.

13. A system as claimed in any preceding claim, wherein the controller (10) includes an intra-array comparison stage which allocates each pixel a specific spectral content partly in dependence on the spectral radiance of other pixels.

14. A system as claimed in any preceding claim, wherein the controller (10) includes a histogram manipulation stage (18) which operates on a spectral radiance value, a grey scale value being allocated to each pixel in accordance with the number of pixels having a value in any one range to maximise grey scale contrast.

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty☐

For receiving Office use only

International Application No☐

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum) X61703

Box No☐I TITLE OF INVENTION

AN IMAGING SYSTEMS

Box No☐II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation☐The address must include postal code and name of country☐The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below☐)*

BAE SYSTEMS Avionics Limited
Warwick House
P O Box 87
Farnborough Aerospace Centre
Farnborough, Hampshire
GU14 6YU, United Kingdom

☐ This person is also inventor☐

Telephone No☐
01252 384628

Facsimile No☐
01252 383091

Teleprinter No☐

State *(that is, country)* of nationality:
GB

State *(that is, country)* of residence:
GB

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No☐III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation☐The address must include postal code and name of country☐The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below☐)*

JACK, James W
Blackford
3 Midmar Avenue
Edinburgh
EH10 6BS
United Kingdom

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below☐)*

State *(that is, country)* of nationality:
GB

State *(that is, country)* of residence:
GB

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on a continuation sheet☐

Box No☐IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation☐The address must include postal code and name of country☐)*

ROONEY, Paul Blaise
BAE SYSTEMS plc
Group IP Department
Lancaster House, P.O. Box 87
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Farnborough, Hampshire, GU14 6YU
United Kingdom

Telephone No☐
01252 383987

Facsimile No☐
01252 383091

Teleprinter No☐

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent☐

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- ☒ AP **ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, MZ Mozambique, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ EA **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ EP **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ OA **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- ☒ AE United Arab Emirates
- ☒ AG Antigua and Barbuda
- ☒ AL Albania
- ☒ AM Armenia
- ☒ AT Austria
- ☒ AU Australia
- ☒ AZ Azerbaijan
- ☒ BA Bosnia and Herzegovina
- ☒ BB Barbados
- ☒ BG Bulgaria
- ☒ BR Brazil
- ☒ BY Belarus
- ☒ BZ Belize
- ☒ CA Canada
- ☒ CH and LI Switzerland and Liechtenstein
- ☒ CN China
- ☒ CR Costa Rica
- ☒ CU Cuba
- ☒ CZ Czech Republic
- ☒ DE Germany
- ☒ DK Denmark
- ☒ DM Dominica
- ☒ DZ Algeria
- ☒ EE Estonia
- ☒ ES Spain
- ☒ FI Finland
- ☒ GB United Kingdom
- ☒ GD Grenada
- ☒ GE Georgia
- ☒ GH Ghana
- ☒ GM Gambia
- ☒ HR Croatia
- ☒ HU Hungary
- ☒ ID Indonesia
- ☒ IL Israel
- ☒ IN India
- ☒ IS Iceland
- ☒ JP Japan
- ☒ KE Kenya
- ☒ KG Kyrgyzstan
- ☒ KP Democratic People's Republic of Korea
- ☒ KR Republic of Korea
- ☒ KZ Kazakhstan
- ☒ LC Saint Lucia
- ☒ LK Sri Lanka
- ☒ LR Liberia
- ☒ LS Lesotho
- ☒ LT Lithuania
- ☒ LU Luxembourg
- ☒ LV Latvia
- ☒ MA Morocco
- ☒ MD Republic of Moldova
- ☒ MG Madagascar
- ☒ MK The former Yugoslav Republic of Macedonia
- ☒ MN Mongolia
- ☒ MW Malawi
- ☒ MX Mexico
- ☒ MZ Mozambique
- ☒ NO Norway
- ☒ NZ New Zealand
- ☒ PL Poland
- ☒ PT Portugal
- ☒ RO Romania
- ☒ RU Russian Federation
- ☒ SD Sudan
- ☒ SE Sweden
- ☒ SG Singapore
- ☒ SI Slovenia
- ☒ SK Slovakia
- ☒ SL Sierra Leone
- ☒ TJ Tajikistan
- ☒ TM Turkmenistan
- ☒ TR Turkey
- ☒ TT Trinidad and Tobago
- ☒ TZ United Republic of Tanzania
- ☒ UA Ukraine
- ☒ UG Uganda
- ☒ US United States of America
- ☒ UZ Uzbekistan
- ☒ VN Viet Nam
- ☒ YU Yugoslavia
- ☒ ZA South Africa
- ☒ ZW Zimbabwe

Check-box reserved for designating States which have become party to the PCT after issuance of this sheet:

☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

Box No☐VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box☐

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) 30/09/99 30 September 1999	9923013.8 ✓	GB		
item (2) 30 May 01 / 20 mos				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4☐0(b)(ii))☐See Supplemental Box☐*

Box No☐VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)* :

ISA / EP

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date *(day/month/year)* | Number | Country *(or regional Office)*

Box No☐VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	: 03
description (excluding sequence listing part)	: 12
claims	: 04
abstract	: 01
drawings	: 03
sequence listing part of description	: -
Total number of sheets	: 23

This international application is **accompanied by** the item(s) marked below:

1☐☒ fee calculation sheet
2☐☐ separate signed power of attorney
3☐☐ copy of general power of attorney; reference number, if any:
4☐☐ statement explaining lack of signature
5☐☐ priority document(s) identified in Box No☐VI as item(s):
6☐☐ translation of international application into (language):
7☐☐ separate indications concerning deposited microorganism or other biological material
8☐☐ nucleotide and/or amino acid sequence listing in computer readable form
9☐☒ other *(specify)*: GB FORM 23/77 REQUEST CERTIFIED COPY

Figure of the drawings which should accompany the abstract: 1B

Language of filing of the international application: ENGLISH

Box No☐IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request)☐

PB Rooney

ROONEY, Paul Blaise

For receiving Office use only

1☐ Date of actual receipt of the purported international application:

2☐ Drawings: ☐ received: ☐ not received:

3☐ Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:

4☐ Date of timely receipt of the required corrections under PCT Article 11(2):

5☐ International Searching Authority (if two or more are competent): ISA /

6☐☐ Transmittal of search copy delayed until search fee is paid☐

For International Bureau use only

Date of receipt of the record copy by the International Bureau: